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HYDROGRAPHIC SURVEY REQUIREMENTS SYSTEM (HYSUR)(U)  
DEFENSE MAPPING AGENCY HYDROGRAPHIC/ TOPOGRAPHIC CENTER  
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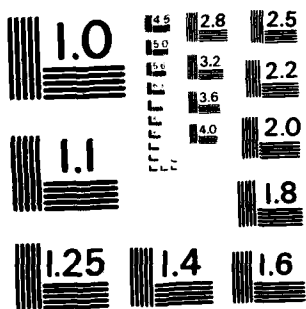
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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
	A131115	
4. TITLE (and Subtitle)		5. TYPE OF REPORT & PERIOD COVERED
HYDROGRAPHIC SURVEY REQUIREMENTS SYSTEM(HYSUR)		Final June 1983
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s)		8. CONTRACT OR GRANT NUMBER(s)
Chung Hye Read		N/A
9. PERFORMING ORGANIZATION NAME AND ADDRESS		10. PROGRAM ELEMENT PROJECT, TASK AREA & WORK UNIT NUMBERS
DMAHTC 6500 Brookes Lane Brookmont, MD 20315		N/A
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE
Scientific Data Department Techniques Office(SDT)		June 1983
		13. NUMBER OF PAGES
		8
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report)
Defense Mapping Agency Bldg. 56, US Naval Observatory Washington, DC 20305		Unclassified
		15a. DECLASSIFICATION DOWNGRADING SCHEDULE
6. DISTRIBUTION STATEMENT (of this Report)		
Approved for open publication		
7. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
For presentation @ the Sixth International Symposium on Automated Cartography, 16-21 October 1983, Ottawa, Canada		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)		
MC & G data acquisition, hydrographic survey requirements, mission area, cell structure, rank order, and survey planning.		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)		
The Defense Mapping Agency(DMA) has no automated system with which to determine the survey precedence of the 8.2 million square nautical miles of worldwide coastal areas which require hydrographic surveying. In response to this vast requirement, the DMA Hydrographic/Topographic Center(HTC) is developing the hydrographic Survey Requirements System(HYSUR). This software system will enable managers to make timely, systematic decisions, thereby enhancing the utility of the Naval Oceanographic Office(NAVOCEANO) survey vessels. This report discusses the practical applications of this system which will identify		

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HYDROGRAPHIC SURVEY REQUIREMENTS SYSTEM (HYSUR)

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ABSTRACT

The Defense Mapping Agency (DMA) has no automated system with which to determine the survey precedence of the 8.2 million square nautical miles of worldwide coastal areas which require hydrographic surveying. In response to this vast requirement, the DMA Hydrographic/Topographic Center (HTC) is developing the Hydrographic Survey Requirements System (HYSUR). This software system will enable managers to make timely, systematic decisions, thereby enhancing the utility of the Naval Oceanographic Office (NAVOCEANO) survey vessels. This report discusses the practical applications of this system which will:

- a. Identify hydrographic data deficiency areas.
- b. Establish a rank order for required survey areas considering economic, political, military, and physical factors.
- c. Provide an alternative planning capability to answer management-level "What if" questions, such as: "What if a given route is blocked?", or "What if merchant traffic is disregarded?".
- d. Produce *coastal requirements* survey program *plans* based on the results of the ranking procedures, available resources, and estimated cost.

INTRODUCTION

The Hydrographic Survey Requirements System (HYSUR) is a *planned* ~~proposed~~ software system that will enhance the Defense Mapping Agency's (DMA) utilization of limited hydrographic survey resources to accomplish needed surveys. HYSUR will provide an automated method to assess existing source material coverage of the required areas, and to establish weighting factors based on economic, political, geomorphological, and military considerations in order to determine hydrographic survey priorities for required geographic areas.

An automated file will be maintained on both the mission areas, which will be defined, and their subdivisions, called cell areas. This will be a static data file that identifies cell area size, as well as the degree of safe passage for specific coastal areas. A dynamic data file containing merchant and military traffic volume and strategic resources movement data will also be included. Additional files will include information about foreign charts, a remote sensing suitability index, and identification of countries with which the United States has mapping and charting agreements. Another HYSUR file will identify countries that the U.S. supports through the Hydrographic Survey Assistance Program. All files will be further explained in a later section.

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HYSUR will be implemented on a UNIVAC 1100/62 computer utilizing the System 2000 data base management system.

#### BACKGROUND

The Defense Mapping Agency has a statutory responsibility\* to provide accurate nautical charts of areas outside U.S. territorial waters for both civil and military maritime uses. DMA tasks the Naval Oceanographic Office (NAVOCEANO) to collect hydrographic ship survey data for specific geographic areas. Upon completion of each survey, the raw data are sent to HTC to be evaluated. The evaluated data and related information are indexed and stored for eventual use in the preparation of hydrographic products.

Prior to 1978, DMA's total coastal hydrographic data collection requirement was approximately 17 million square nautical miles. This estimate was derived by multiplying the 244,000 miles of worldwide coastline by an assumed average continental shelf width of 70 miles. To develop a more realistic estimate of coastal survey requirements, DMA conducted the Coastal Survey Requirements Study, commonly referred to as the Chubb Study, in fiscal year 1978. This study established the concept of DMA mission areas (those areas between six and 300 fathoms in depth, having heavy traffic volume and containing major coastal routes as well as significant ports and the approaches thereto). This reduced the original requirement of 17 million square nautical miles to 8.2 million square nautical miles; however, this still represented more than 200 ship-years of survey effort. The magnitude of that effort and limited survey resources still precluded a comprehensive coastal survey program within a reasonable time frame. Hence, DMA elected to develop a systematic method to establish survey priorities for hydrographic areas.

#### PURPOSE

Currently, when HTC is tasked to provide a hydrographic product, the areas to be charted are first plotted to determine existing DMA chart coverage of each area. Other hydrographic data in the required areas are acquired by searching various non-automated data files such as the foreign chart card file, foreign chart catalogs, and the International Hydrographic Organization (IHO) Bulletins. After evaluating all available information, a decision is made as to whether a hydrographic survey is necessary or whether existing data meet the user's requirement. If hydrographic surveys are deemed necessary, area specialists determine the ranking of the survey areas. The necessary survey planning may take up to a year.

With the increasing number of deep-draft vessels and submarines, a growing need for detailed, reliable charts exists. This need, coupled with the 200 year backlog of coastal survey requirements, results in an urgent requirement to establish rational priorities that will support an efficient program to systematically satisfy the backlog of coastal survey requirements.

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\*Title 10, U.S. Code 7391, et seq., Chapter 639.

#### SYSTEM FUNCTIONS

The following system objectives have been developed in order to enhance hydrographic resource management and to assist planners in establishing priorities for survey requirements:

- a. Identify deficiencies in hydrographic data by providing graphic and/or textual reports depicting shoreline and existing hydrographic data coverage for all coastal areas.
- b. Establish a rank order for required survey areas using factors based on civil and military traffic volumes, commodity movements, and physical characteristics for each area.
- c. Provide an alternative planning capability to answer management level "what if" decision questions, such as "what are alternative routes if a given route is inaccessible" or "what if merchant traffic is disregarded?"
- d. Develop survey ~~plans~~ <sup>requirements</sup> based on the results of the ranking procedures and available survey resources.

#### APPROACH

##### Automation

Prior to the implementation of HYSUR, several data files and file indices must be automated. These files include:

- a. foreign chart file, containing information on HHC's holdings of foreign charts that is currently recorded on 1500 3 X 5 inch index cards;
- b. Bilateral International Agreement file, identifying countries whose charts the U.S. may reproduce; and
- c. Listing of Surveys and Charts from the Hydrographic Survey Assistance Program.

In addition, the following files must be created:

- a. a new related products file containing area coverage and status information on in-process and recently completed foreign charts.
- b. a survey progress file containing planned, in-process, and recently completed U.S. and foreign hydrographic surveys.
- c. a static data file containing mission area information, such as cell names, sizes, types, degree of safe passage and established, optimum shipping routes.
- d. a dynamic data file containing information on merchant and military surface and subsurface traffic volumes, and strategic resource movements.
- e. a remote sensing suitability index file which will be loaded as data becomes available. This index will be designed to identify areas suitable for the collection of required hydrographic

data utilizing remote sensing technology.

#### Cell Structure

HYSUR will broaden the concept of the Chubb Study's mission area from 6 - 300 fathom depths to 0 - 1000 fathom depths in order to accommodate all civil and military requirements. Mission areas will be subdivided into smaller areas called cells based on depth, geomorphological characteristics, and military and civilian usage. Cells will be categorized as Coastal Cells (with depths from 6 - 1000 fathoms along one body of land), Strait Cells (with depths from 6 - 1000 fathoms, located between two physically close land areas and through which maritime traffic will occur on each land side), Harbor Cells (with depths from 0 - 1000 fathoms in which vessels may dock or anchor for cargo loading or transfer), and Amphibious Assault/Combat Cells (coastal areas with depths from 0 - 1000 fathoms designated for military operations).

After the mission areas of the world are segmented into appropriate cells, the size of each cell will be measured using a planimeter on small scale world charts overlayed with the appropriate cell structure. Cell sizes will be loaded into the static data file, and will be available as an additional factor to determine the application of survey resources.

#### Identification

HYSUR will access information on hydrographic source coverage for each desired cell area through interfaces with several existing DMA data bases (such as, the Area Requirements And Product Status System (ARAPS) and the Bathymetric Information System (BIS)) and HYSUR data files. ARAPS will provide information on area requirements including priority, production status, chart evaluation, and intended use. BIS will provide information on bathymetric surveys. HYSUR will automatically identify source data deficiencies and highlight needed survey areas.

#### Value

A numerical ranking value will be derived for each cell based upon the characteristics of actual and potential civilian and military usage for each cell. A cell with a high rank value has a higher survey priority than a cell with a lower rank value. The following factors are involved in the computation of the cell weight:

Wt: Cell Weight  
SR: Strategic Resource Weight (range 0 to 100)  
MT: Merchant Shipping Weight  
S: Submarine Operations Weight (range 0 to 99)  
B: Mine Warfare Weight (range 0 to 99)  
J: Mapping, Charting, and Geodesy (MC&G) Priority (range 1 to 5)

This relationship is expressed in the following equation (Eq. 1):

$$Wt = \frac{SR + MT + S + B}{J} \quad (1)$$



Strategic Resource Weight. The strategic resource weight, SR, represents the percentage of U.S. imports of all strategic materials on designated shipping routes. For example, if 92% of all commodities transported on a specified shipping route is delivered to the U.S.\*, then SR is assigned a value of 92.

Merchant Shipping Weight. The merchant shipping weight, MT, is expressed as follows (Eq. 2):

$$MT = WT \times (1 - dm/wm) \quad (2)$$

where,

WT: Importance factor of port or route (range 0-100)  
 dm: Distance in nautical miles from the 20-1000 fathom depths  
 wm: Distance in nautical miles from the 6-1000 fathom depths  
 (1-dm/wm): Degree of safe passage for merchant vessels  
     (1 - dm/wm) - 0: Relatively safe passage  
     (1 - dm/wm) - 1: Limited safe passage

Equation 2 portrays the risk factor for important merchant shipping through certain areas. The greater the risk, the higher the merchant weight.

The importance factor of a port or route, WT, is derived as follows (Eq. 3):

$$WT = WC \times WV \quad (3)$$

where,

WC: Strategic importance of cargo, derived from the commodity code (range 0-10)  
 WV: Factor derived from the volume of cargo

Equation 3 quantifies the importance of the port or route by relating the volume and type of cargo, thereby preserving the significance of small shipments of strategic materials.

Strategic Importance. The strategic importance, WC, is a number assigned to each strategic commodity according to its importance to the U.S. It ranges from 0 (no strategic importance) to 10 (great strategic importance).

Cargo Volume. The optimum basis for measuring merchant trade is generally considered to be by volume or tonnage. However, the only readily available comprehensive base of statistics for world trade was found to be expressed as cargo value in U.S. dollars. The cargo value has a wide range, i.e., from \$1 million to \$1 trillion. In order to effectively weight this large range of data, cargo volume, WV, is expressed logarithmically (e.g., a cargo value of \$100 million reflects a cargo volume WV = 1, for \$1 billion WV = 11; and for \$1 trillion, WV = 31).

\*Extracted from U.S. Oceanborne Trade Statistics and the Yearbook of International Trade Statistics, and will be contained in the dynamic data file.

The following three examples demonstrate the computation of merchant shipping weight:

Example 1 - A cell with \$1 billion (WV = 11) worth of platinum cargo (WC = 4) will have a route importance factor, WT, of 44.

$$WT = WC \times WV = 4 \times 11 = 44$$

Example 2 - If the cargo in Example 1 is routed through a cell where the distance from the 20 fathom depth to the 1000 fathom depth is 150 nautical miles, and the distance between the 6 fathom depth to the 1000 fathom depth is 450 nautical miles, that cell will have a merchant weight of 29.

$$\begin{aligned} MT &= WT \times (1 - dm/wm) \\ \text{From example 1, } WT &= 44 \\ WT &= WC \times WV = 11 \times 4 = 44 \end{aligned}$$

Therefore,

$$MT = 44 \times (1 - 150/450) = 29$$

Example 3 - If the cargo in Example 1 must pass through a cell with 150 nautical miles between the 20 fathom depth and the 1000 fathom depth, and 300 nautical miles between the 6 fathom and the 1000 fathom depth, the merchant weight is 22.

$$MT = 44 \times (1 - 150/300) = 22$$

Since Example 2 expresses a higher navigational risk, 2/3, than Example 3, 1/2, the area in Example 2 has a higher merchant shipping weight.

Submarine Operations Weight. The submarine operations weight, S, is expressed as follows (Eq. 4):

$$S = WS \times (1 - ds/ws) \quad (4)$$

where,

WS: Submarine weighting factor (0 or 99)  
ds: Distance in nautical miles from the 300 - 1000 fathom depths  
ws: Distance in nautical miles from the 20 - 1000 fathom depths  
(1 - ds/ws): Degree of safe passage for submarines  
          (1 - ds/ws) → 0: Relatively safe passage  
          (1 - ds/ws) → 1: Limited safe passage

If a cell area is designated as a possible submarine interest area, the submarine weighting factor is 99; if not, 0 is applied to that cell. The degree of safe passage for submarines is analogous to that for merchant shipping.

Mine Warfare Weight. The mine warfare weight, B, is derived as follows (Eq. 5):

$$B = WB \times (1 - db/wb) \quad (5)$$

where,

WB: Mine warfare factor (0 or 99)  
 db: Distance along the narrowest passage with a depth of 1000 fathoms  
 wb: Total length of the passage  
 (1 - db/wb): Degree that traffic may be blocked  
           (1 - db/wb) → 0: minimum blockage attainable  
           (1 - db/wb) → 1: maximum blockage attainable

If a cell area is designated as a potential mine warfare area, the mine warfare factor of 99 is assigned; if not, a factor of 0 is applied to that cell.

Example 4 - A cell is designated as a potential mine warfare area. The distance along the narrowest passage with a depth of 1000 fathoms is 30 nautical miles and the total length of the passage is 300 nautical miles. The mine warfare weight for this cell is 89.

$$B = WB \times (1 - db/wb) = 99 \times (1 - 30/300) = 89$$

MC&G Priority. The MC&G priority, J, is specified in the Joint Strategic Planning Document (JSPD). The priority is expressed as a number ranging from 1 (the highest priority) to 5 (the lowest priority) and is assigned by geographic area. Since the merchant, submarine operation, and mine warfare weights will be divided by the MC&G priority value, MC&G priority plays a primary role in assigning a weight to each cell.

Example 5 - A cell containing an established shipping route on which 92% of commodity trade is imported by the U.S. has the same merchant weight as shown in Example 2. If a submarine operation weight of 99, a mine warfare weight of 0, and a hypothetical MC&G priority of 2 is assigned to that cell, then the cell weight will equal 152.5.

$$Wt = SR + \frac{MT + S + B}{J}$$

$$Wt = 92 + \frac{22 + 99 + 0}{2} = 152.5$$

Example 6 - If the cell in Example 5 has an MC&G priority of 1, Wt is increased to 213.

$$Wt = 92 + \frac{22 + 99 + 0}{1} = 213$$

Weighting factors can be used in any combination. For instance, one or more weighting factors can be deleted or any weighting factor can be increased during calculation to suit a user's specific purpose.

#### Planning

After a cell is assigned a numerical value based on the weighting factor, a survey precedence is established. The product requirement (type of chart, scale, geographical position, intended use, etc.), data deficiencies, urgency of the requirement, political accessibility, bilateral agreements, as well as the weighting factors for a cell are utilized in the survey area ranking procedure. To minimize transit times, the system weights all cells and then groups the cells by geographic proximity. A Survey Requirement Planning Report in the form of textual information in soft or hardcopy form will then be produced. The system will also produce a magnetic tape for hardcopy plot generation. This graphic plot will portray the mission area, cell area, priority, shoreline, DMA chart coverage, other source coverage, volume of merchant and military traffic, planned and in-process surveys, strategic resource movements, and ship routes.

#### CONCLUSION

The potential benefits from this <sup>Planned</sup>~~proposed~~ system, when it is fully operational in 1985, are that DMA and NAVOCEANO planners can make more effective and timely decisions by virtually eliminating the intensive manual and semi-automated activities to determine priorities for required hydrographic surveys. The cost of operating a survey ship, approximately \$30,000 per day, accentuates the potential savings of an effective management planning system like HYSUR. Even more important, however, is the resulting capability to apply limited resources to satisfy the most critical survey requirements. Thus, more effective use of extremely limited resources can be achieved. Rapid deployment programs and crisis areas can also be more easily supported by allowing ready retrieval of source information for decision making.

Continuing emphasis must be given to other ways of acquiring needed hydrographic data. With rapidly changing technology, hydrographic data acquisition will not depend solely on existing conventional surveys. Utilization of space sensors, such as multispectral scanning systems, synthetic aperture radars, thermal band scanners, or airborne sensors (e.g., the Hydrographic Airborne Laser Sounder) will be employed. HYSUR will be designed to accommodate these systems.

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